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POLYALKYLENE GLYCOL AS A TRANSDUCER FLUID

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Polyalkylene glycol has been suggested as a replacement for DB grade castor oil in underwater sound transducers, primarily because of its low viscosity. The results of measurements reported here show that polyalkylene glycol is at least as compatible as castor oil with butyl and neoprene Type W rubbers, and it is only somewhat less compatible with neoprene 35003 and natural rubber 35007.

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POLYALKYLENE GLYCOL AS A TRANSDUCER FLUID

Introduction

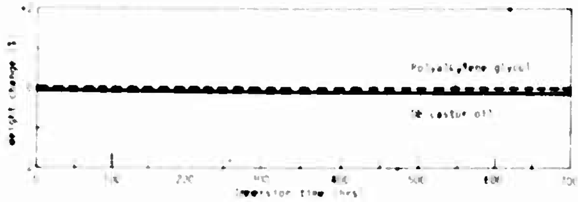
Various liquids are used as acoustic transfer mediums in underwater sound devices. Baker's DB grade castor oil is the liquid principally used by the Underwater Sound Reference Division of the Naval Research Laboratory in Navy standard calibration transducers. The advantages of castor oil include relatively good acoustic impedance match to water, high dielectric strength, high electrical resistivity, low cost, and compatibility with other transducer materials. A disadvantage has always been its high viscosity, 7.5 St, at room temperature, which is even more of a problem at lower temperatures--50 St at 4°C. For this reason, other fluids have been investigated in the past [1,2] as possible replacements for castor oil; however, until now, all of these have been inferior to castor oil in one respect or another.

Recent studies at the Naval Undersea Center (NUC) reported by Green [3,4] show that polyalkylene glycol, manufactured by Union Carbide under the designation UCON YT 11273, is a suitable liquid for use in underwater transducers. Some of the characteristics of polyalkylene glycol that are important in the application to underwater sound were found equal to or superior to those of castor oil, such as its notably low viscosity (1.5 St at 4°C).

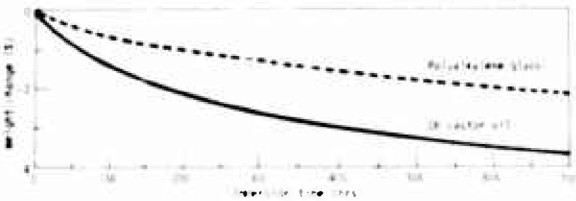
Green also reported the chemical compatibility of the polyalkylene glycol with transducer materials was the same as that of castor oil; however, this appeared to be a comparison measurement relative to an obvious incompatibility between a phenol polysiloxane, DC 510 (Dow Corning), and several other materials. Chemical compatibility is a particularly important characteristic of a sonar transducer medium because it remains in intimate contact with other components such as elastomers for very long periods of time, and it is imperative that these components be unaffected by the medium. For this reason, it was felt necessary to make more detailed measurements of the compatibility between polyalkylene glycol and several selected elastomer compounds. This compatibility study is the subject of this report.

Measurements

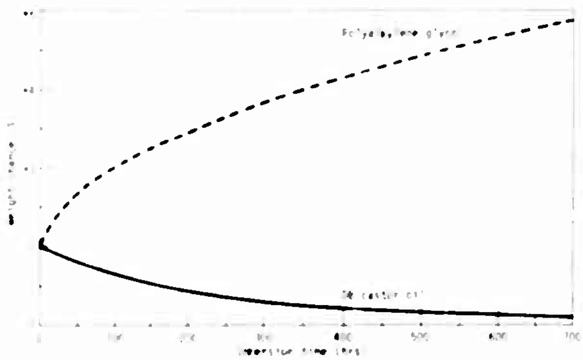
The elastomers most often used in standard underwater transducers at the USRD are butyl NASL-H862A, Type W neoprene G6470, natural rubber 35007, and neoprene 35003. The compound ingredients of these elastomers are given in Appendix A. Test specimens of each elastomer compound were prepared and tested in accordance with the applicable ASTM standards,



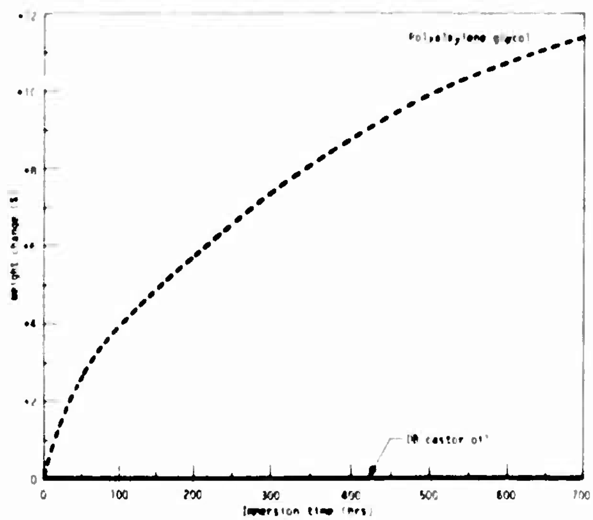
(a) Butyl H862A



(b) Neoprene Type W



(c) Neoprene 35003



(d) Natural rubber 35007

Fig. 1. Weight change of elastomers with time of immersion in polyalkylene glycol and castor oil.

"Change in Properties of Elastomeric Vulcanizates Resulting from Immersions in Liquids" [5] and "Indentation Hardness of Rubber and Plastics by Means of a Durometer" [6]. Each specimen was 25 mm wide by 40 mm long by 6 mm thick. The immersion temperature 50°C was chosen to accelerate effects of the fluids. The total immersion period was 750 h; parameter measurements were made initially and after 24, 96, 120, 168, 264, 336, 408, 480, 624, and 750 h. Identical test specimens were immersed in Baker's DB grade castor oil and polyalkylene glycol for measurement of relative comparison data as well as absolute changes. The characteristics measured were change in weight, change in volume or swell, and change in hardness.

The change in weight experienced by the elastomers as a function of immersion time is shown in Fig. 1. Butyl H862A is completely unaffected by the polyalkylene glycol and the castor oil. Neoprene Type W exhibits a weight decrease for both fluids, thus indicating dissolution of the elastomer. It should be noted the neoprene is less affected by the polyalkylene glycol than the the castor oil. Neoprene 35003 is also dissolved by the castor oil, but both neoprene 35003 and natural rubber 35007 absorb polyalkylene glycol. The natural rubber is unaffected by castor oil. Rubbers generally absorb fluids by a diffusion-controlled process and, until equilibrium is reached, the mass of liquid absorbed is proportional to the square root of the immersion time as illustrated by the results of this study shown in Fig. 2. The percentage weight gain experienced by the natural rubber 35007 and the neoprene 35003 can be described respectively by the equations

$$\frac{\Delta M}{M}\,\% = 265 . t^{0.58} \tag{1}$$

and

$$\frac{\Delta M}{M}\,\% = 0.157\ t^{0.55} \tag{2}$$

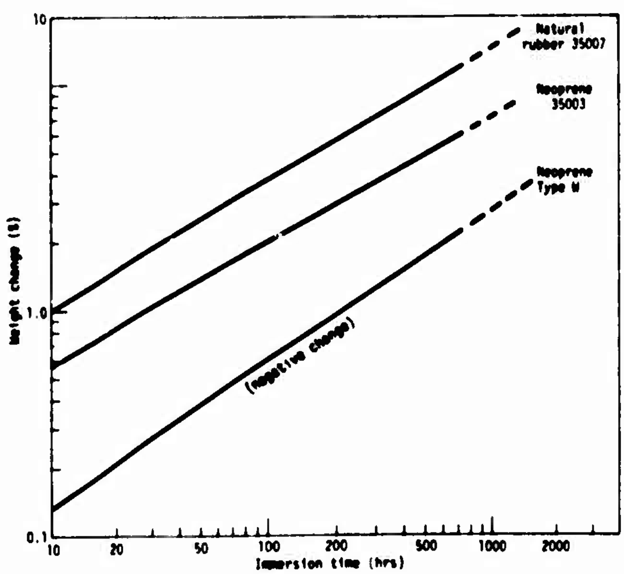


Fig. 2. An indication of the square-root-dependence of absorption of polyalkylene glycol upon immersion time.

Thus it is clear the weight gain observed for natural rubber 35007 and neoprene 35003 is a diffusion-controlled process of polyalkylene glycol absorption. On the other hand, the decrease in weight of the neoprene Type W, given by

$$\frac{\Delta M}{M} \% = 0.029 \; t^{-0.66} \qquad (3)$$

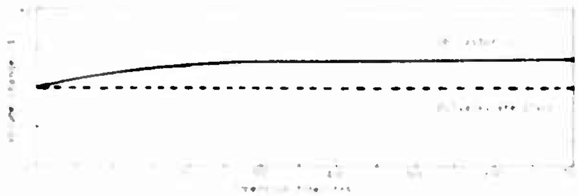
implies that its solubility in the polyalkylene glycol is a little more complicated than a simple diffusion process.

The percentage change in volume as a function of immersion time is shown in Fig. 3. Butyl and neoprene are not seriously affected by either castor oil or polyalkylene glycol. As might be expected from the weight-gain data, the neoprene 35003 and natural rubber 35007 do swell from the amount of polyalkylene glycol they absorb.

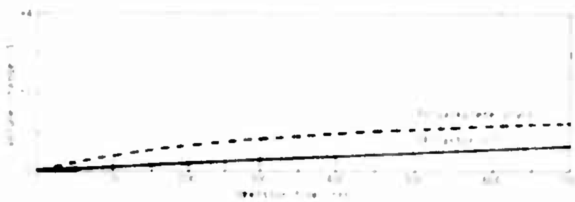
The hardness of an elastomer can be related indirectly to its Young's modulus. In this study, however, the change in the Shore durometer hardness has been recorded only as an indicator of relative compatibility with fluids. For butyl, neoprene Type W, and natural rubber the hardness decreases rapidly to a value which appears to be stable with longer immersion times. Again, the butyl rubber seems to be affected least by immersion and to be more compatible with polyalkylene glycol than with castor oil. Only in the case of neoprene 35003 does the hardness continue to change with immersion time in polyalkylene glycol. The effect of immersion time on the Shore hardness is shown in Fig. 4.

Conclusions

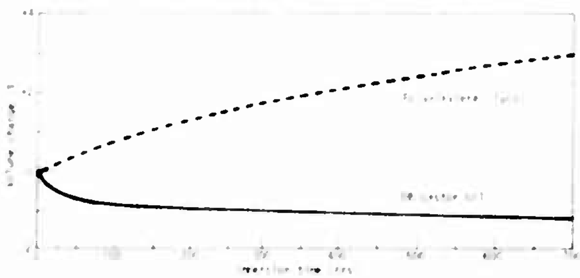
As used here, the term "incompatible" describes any liquid-elastomer combination that results in a physical change that would decrease the lifetime or effectiveness of a transducer. Such changes could include change of weight, hardness, or dimension of the elastomer. It would be difficult for a designer to choose an elastomer-liquid combination that would be absolutely free of interactions between the materials; hence, the choice usually is based on relative compatibility. Years of successful experience with DB grade castor oil support the acceptance of its compatibility with the elastomers used in transducers; this study shows polyalkylene glycol to be equal to or better than castor oil when used with butyl H862A or neoprene Type W rubbers. Natural rubber 35007 and neoprene 35003 absorb polyalkylene glycol and tend to swell with a resulting decrease in hardness more than with DB castor oil. However, in a relative sense, natural rubber 35007 and neoprene 35003 are more compatible with polyalkylene glycol by a factor of about 3 than with lubricin castor oil [2] and much better than with a phenol polysiloxane. Some caution should be exercised in the use of these fluids with natural rubber 35007 and neoprene 35003.



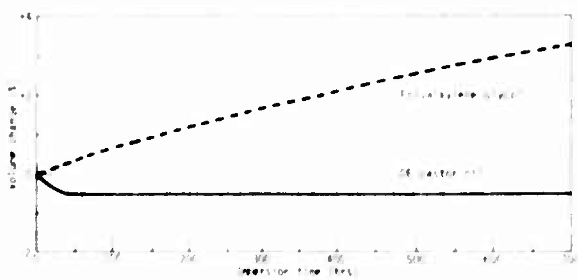
(a) Butyl H862A



(b) Neoprene Type W

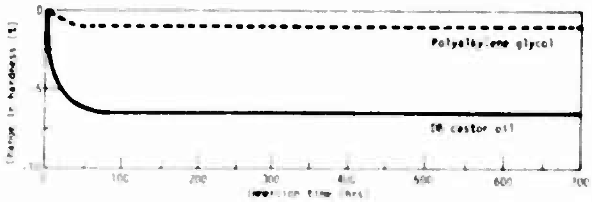


(c) Neoprene 35003

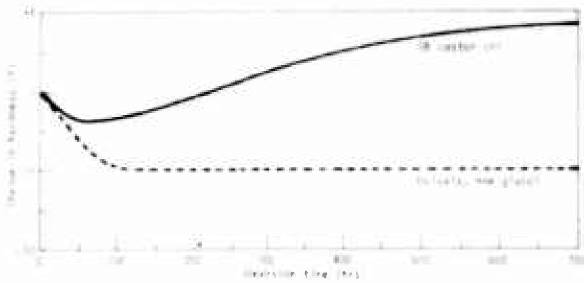


(d) Natural rubber 35007

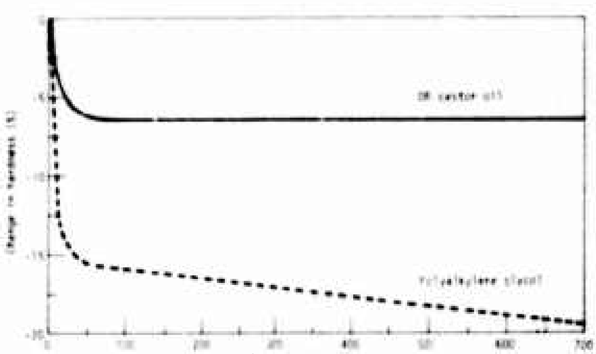
Fig. 3. Dimensional change of elastomers with time of immersion in polyalkylene glycol and castor oil.



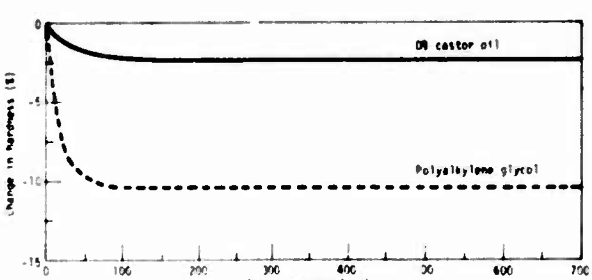
(a) Butyl H862A



(b) Neoprene Type W



(c) Neoprene 35003



(d) Natural rubber 35007

Fig. 4. Effect of immersion time on Shore durometer hardness.

As is usually the case a definite "yes" or "no" cannot be made with regard to the question of compatibility of polyalkylene glycol and all elastomers. It does appear that polyalkylene glycol is an attractive alternative as a transducer fluid, especially when low viscosity is required.

Acknowledgments

A great deal of appreciation is due Mr. E. W. Thomas and Mr. Sam Viola for their assistance in collecting the data.

References

[1] R. W. Timme, "Speed of Sound in Several Liquids," NRL Memorandum Report 2443, 9 June 1972 [AD-743 885].

[2] R. W. Timme, "Lubricin Castor Oil: A Candidate for Underwater Sound Transducers," JUA(USN) 23, 339-341 (1973).

[3] C. E. Green, "Polyalkylene Glycol as a Transducer Liquid," NUC TP 390 (May 1974).

[4] C. E. Green, "An All-Purpose Fluid for Filling Sonar Transducers," J. Acoust. Soc. Amer. 56 Supplement, 531 (1974).

[5] "Standard Method of Test for Change in Properties of Elastomeric Vulcanizates Resulting from Immersions in Liquids," ASTM D 471 - 72 (American Society for Testing Materials, Philadelphia, 1972).

[6] "Standard Method of Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer," ASTM D 2240 - 68 (American Society for Testing Materials, Philadelphia, 1968).

Appendix A
Elastomer Formulations

NASL-H862A butyl and Type W neoprene G6470 were compounded by Smithers Laboratories, Inc., from the following ingredients. The compositions of natural rubber 35007 and neoprene 35003 are considered proprietary trade information by the manufacturer, B. F. Goodrich, and are therefore not available.

Butyl Rubber Compound NASL-H862A

Ingredient	*phr*
Chlorobutyl HT-1066	100
Sterling V black	50
Litharge	10
Stearic acid	1
AC polyethylene 617A	3
DPG	2
Maglite M	1
Zinc oxide	5
NA-22	1.5

Neoprene Compound G6470

Ingredient	*phr*
Neoprene W	75
Neoprene WHV	25
Zinc oxide	5
Magnesium oxide	4
Stearic acid	0.5
Antiox 2246	2
Dioctyl sebacate	10
Iceberg clay	40
Titanox (TiO_2)	15
NA-22	0.5
Cyanamid blue	0.15